

## Distribution and Concentrations of Selected Organochlorine Pesticides and PCB's in Streambed Sediment and Whole-Body Fish in the Upper Colorado River Basin, 1995–96

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As a part of the U.S. Geological Survey National Water-Quality Assessment (NAWQA) Program, hydrologic and water-quality assessment of the Upper Colorado River Basin (UCOL) study unit began in 1994. Prior to the design of the integrated studies of water quality in the basin, a retrospective investigation was conducted to determine the availability of historical water-quality data and the location of previous research that occurred in the UCOL. The findings indicated that minimal data had been collected regarding the occurrence and distribution of organochlorine pesticides and polychlorinated biphenyls (PCB's) in streambed sediment and whole-body fish in the UCOL study unit (Deacon and Stephens, 1996).

Organochlorine pesticides and PCB's, all of which are organochlorine compounds, have been specifically targeted by standards and guidelines that exist to protect water quality for human and wildlife health. In 1995–96, a survey of selected organochlorine pesticides and PCB's was conducted in the UCOL to (1) determine their distribution and concentrations in streambed sediment and whole-body fish, and (2) compare these concentrations to established water-quality guidelines.

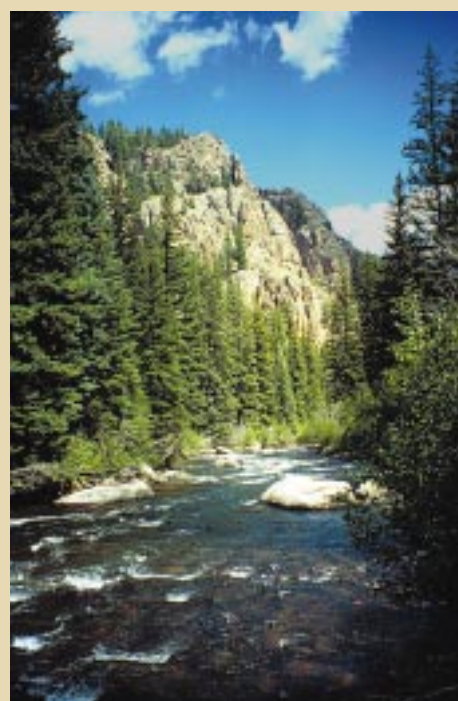
**Organochlorine compounds are unique because their presence can result only from human activities.** These compounds disperse from their original point of application, typically agricultural fields

and urban areas, to the hydrologic system through soil erosion, runoff, and precipitation. Due to the persistence, bioaccumulation, and hazards of these compounds, the use of many organochlorine pesticides has been banned or severely restricted in the United States. Organochlorine compounds are extremely persistent in the environment and have the unique property of concentrating in sediment and in the fatty tissue of aquatic life (Ware, 1989).

This fact sheet presents data for detections of selected organochlorine compounds in streambed sediment and whole-body fish. Data for all the compounds detected in samples collected for this study are in the U.S. Geological Survey National Water Information System (NWIS) data base.

### Description of Sampling Unit and Study Approach

The UCOL study unit (fig. 1) encompasses about 17,800 square miles and has varied climate, geology, hydrology, soils, topography, and land uses. Water quality throughout the basin is directly affected by these natural (physiography, altitude, geology, climate, soils) and human (population, land use, water allocation and use) factors (Apodaca and others, 1996). Sampling sites were selected to characterize differences among these environmental settings and various land uses and to acquire addi-



Typical high-elevation stream in the UCOL study unit.

tional data regarding the occurrence and distribution of organochlorine compounds. Sampling sites in the eastern part of the study unit represent a high-altitude environment of small, clear, cool streams dominated by forest and rangeland. Adverse human effects on water quality in these areas predominantly are mining, increasing urban development, recreational use, and hydrologic modifications (dams and diversions). Sampling sites in the western part of the study unit are representative of a more arid climate dominated by larger, warmer, sediment-laden streams. Human effects on water quality

**Table 1.** Sampling-site information

[Sites listed indicate collection of streambed-sediment samples and type of whole-body-fish samples as noted; na, not available; mi<sup>2</sup>, square miles]

Site number (fig. 1)	Site name	Site identifier	Site type	Sample collection date, streambed sediment	Sample collection date, whole-fish tissue	Drainage area (mi <sup>2</sup> )	Type of whole-body-fish sample used for analysis
1	Colorado River below Baker Gulch	09010500	Reference	10/10/95	08/17/95	53	Brown trout
2	French Gulch near Breckenridge	09046530	Mining	10/05/95	na	11	No fish found
3	Blue River below French Gulch	392944106024400	Mining	10/05/95	08/25/95	69	Brown trout
4	Gore Creek at mouth near Minturn	09066510	Urban/Recreation	10/10/95	08/15/95	102	Brown trout
5	East River below Cement Creek	09112200	Urban/Recreation	10/13/95	10/16/95	238	Brown trout
6	Gunnison River at County Road 32	383103106594200	Mixed	10/13/95	08/16/95	2,128	Brown trout
7	Gunnison River below Gunnison Tunnel	09128000	Reference	10/13/95	09/21/95	3,965	Brown trout
8	Uncompahgre River near Ridgway	09146200	Mining	10/12/95	10/17/95	149	White sucker
9	Colorado River at Dotsero	09070500	Mixed	10/10/95	08/23/95	4,394	Brown trout
10	Dry Fork at upper station near De Beque	09095300	Reference	10/11/95	na	97	No fish found
11	Colorado River near Cameo	09095500	Mixed	10/11/95	08/23/95	8,050	Bluehead sucker
12	Dry Creek near Begonia Road	09149480	Agriculture	10/12/95	08/18/95	175	White sucker
13	Tongue Creek near Cory, CO	09144200	Agriculture	10/12/95	08/24/95	200	White sucker
14	Gunnison River near Grand Junction	09152500	Mixed	10/12/95	08/16/95	7,928	Bluehead sucker
15	33 Road drain near mouth	390347108265800	Agricultural drain	09/17/96	na	na	No fish collected
16	Appleton drain near mouth	390624108374900	Agricultural drain	09/17/96	na	na	No fish collected
17	Copeco drain near mouth	390723108400500	Agricultural drain	09/17/96	na	na	No fish collected
18	Reed Wash near Mack	09153290	Agriculture	11/20/95	11/21/95	16	Flannelmouth sucker
19	Colorado River near Colorado-Utah State line	09163500	Mixed	10/11/95	08/17/95	17,843	Bluehead sucker

in these areas are predominantly agriculture, water development, and increasing urban development and recreational use.

Streambed-sediment and whole-body-fish samples were collected in fall 1995 and 1996 (fig. 1, table 1) for analysis of concentrations of organochlorine pesticides and PCB's. Nineteen sites were sampled for streambed sediment and analyzed for 33 organochlorine pesticides and PCB's. Whole-body-fish samples were collected by electroshocking at 14 of



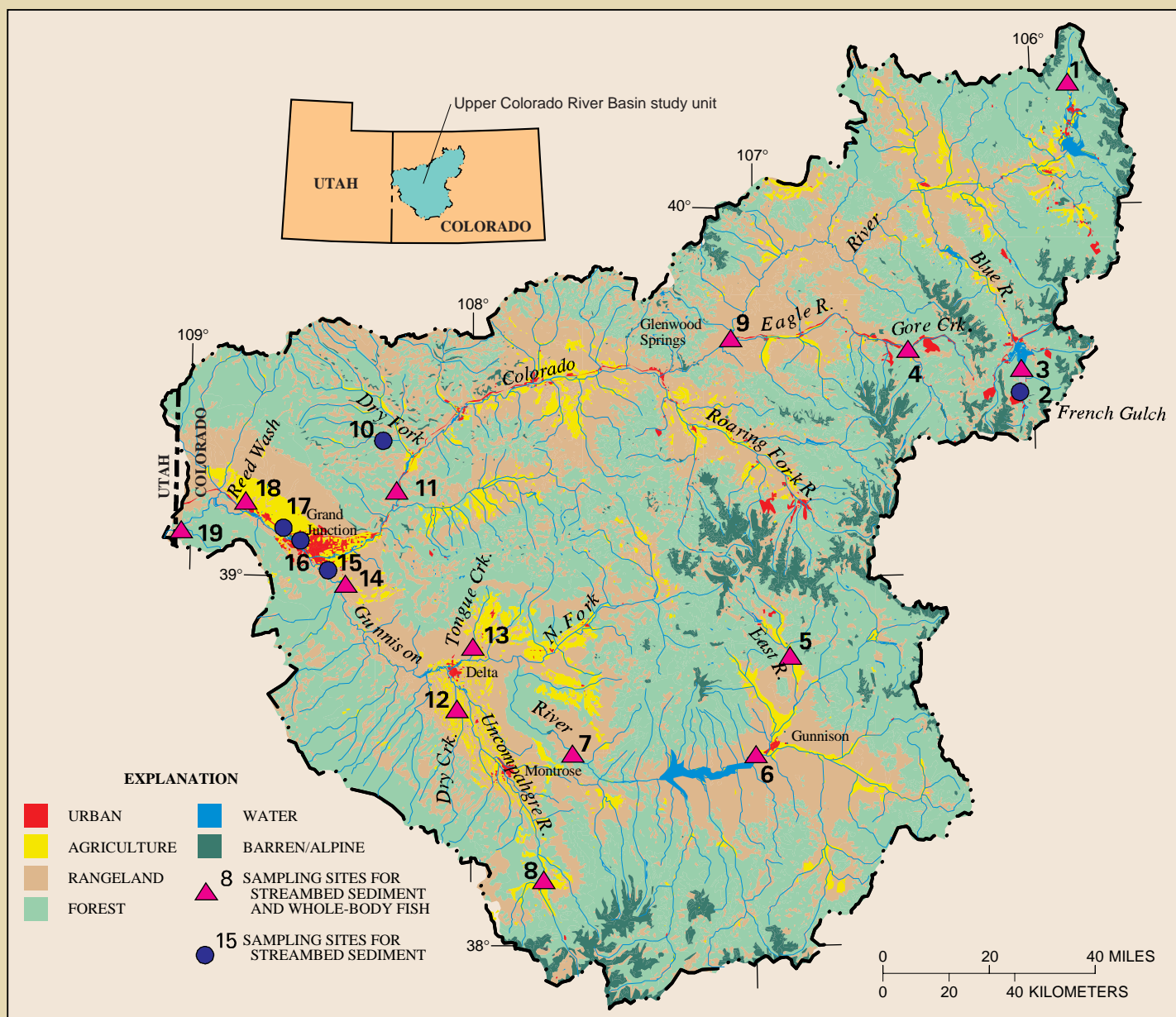
Bed-sediment sample collection.

the sampling sites and were analyzed for 28 organochlorine pesticides and PCB's. Five of the sites sampled for streambed sediment did not contain, or were not sampled, for fish (table 1). Samples of streambed sediment and whole-body fish were collected, processed, and analyzed in accordance with NAWQA protocols (Crawford and Luoma, 1993; Shelton and Capel, 1994). Sample collection was limited to stream reaches that averaged 150–200 meters (m) in length for each of the wadeable sampling sites and 500–750 m in length for the non-wadeable sites. Twenty to 25 individual subsamples of streambed sediment from the upper 2 centimeters were collected from a variety of undisturbed, continuously wetted depositional zones. The subsamples were composited into a glass container, homogenized, and sieved to < 2 millimeters. The samples were then frozen and shipped to a laboratory for analysis. Each of the whole-body-fish samples collected

consisted of a composite of seven similarly sized fish of the same species. The predominant species collected in the eastern higher altitudes was brown trout and the predominant species collected in the western lower reaches of the basin was the sucker. Each fish collected was weighed, measured, sexed, and aged. Fish also were closely scrutinized for signs of disease, parasites, or other abnormal features. Samples were prepared for the organochlorine and PCB analyses by wrapping the individual whole fish in aluminum foil, freezing the sample, and shipping to the laboratory for analysis.







**Figure 1.** Land use and sampling site locations in the Upper Colorado River Basin Study Unit.

## Established Guidelines

The Provincial Sediment Quality Guidelines (PSQG) (Environment Canada, 1995) were used to compare concentrations of organochlorine pesticides and PCB's in streambed-sediment samples collected in this study. These guidelines are based on chronic and long-term effects of contaminant concentrations on benthic organisms. The PSQG establish two assessment values for some of the organochlorine and PCB contaminants analyzed in this study: the lower threshold effect level (TEL) and the higher probable

effect level (PEL). The TEL represents the guideline concentration of sediment contamination below which adverse effects are expected to rarely occur. The PEL represents the guideline concentration above which adverse effects are expected to frequently occur. Concentrations that fall between the TEL and PEL are levels at which adverse effects are expected to occasionally occur (Environment Canada, 1995). The only national guidelines available for evaluating organochlorine-compound concentrations in whole-body fish have been established by the National Academy of Sciences and



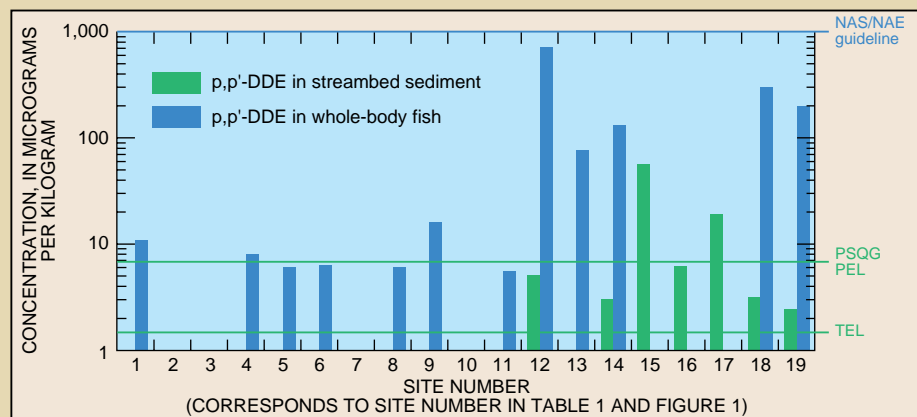
Electroshocking from a boat at a non-wadeable site.

National Academy of Engineering (NAS/NAE). These guidelines apply to the protection of wildlife that consume fish (National Academy of Sciences and National Academy of Engineering, 1973).

## Major Organochlorine Compounds Detected in Relation to Established Guidelines

**Dichloro diphenyl trichloro-ethane (DDT):** DDT is a well-documented, persistent organochlorine compound that has been banned from use in the United States since 1972. The six degradation products of DDT were analyzed for, and the sum of the individual concentrations are denoted as total DDT in this fact sheet. **Total DDT was detected in streambed-sediment samples at 7 of 19 sites and in whole-body-fish samples at 12 of 14 sites (fig. 2).** DDT was the most frequently detected organochlorine compound, with the highest concentrations found in the UCOL study unit. The highest concentrations detected in streambed-sediment samples were collected from sites 15, 16, and 17, which are agricultural drains. Concentrations of the samples collected at these sites exceeded the PSQG TEL of 6.98 µg/kg (micrograms per kilogram) for total DDT. None of the sites exceeded the PEL of 4,450 µg/kg.

Samples collected at sites 3 and 7 had no detections of total DDT in whole-body fish. Samples collected at site 1, a reference site (a reference site is one that is used to determine background or naturally occurring water-quality conditions)



**Figure 3.** Concentrations of p,p'-DDE in streambed sediment and whole-body fish.

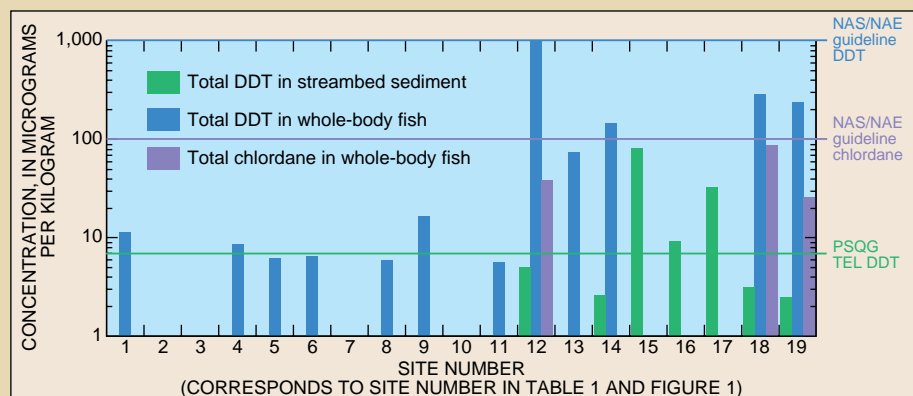
had a total DDT concentration of 11 µg/kg in whole-body fish. This concentration was higher than other samples collected in the eastern, higher altitude sampling sites and might be attributed to residues from applications of DDT to forested areas for the control of spruce budworm in the 1950's (L.F. Carter, U.S. Geological Survey, written commun., 1997). Total DDT concentrations in whole-body fish were highest at agricultural and mixed land-use sites. The concentration of total DDT in whole-body-fish samples collected at site 12 (983 µg/kg), an agricultural site, approached the NAS/NAE guideline of 1,000 µg/kg for the protection of wildlife that consume fish.

**Dichloro diphenyl dichloro-ethylene (p,p'-DDE):** P,p'-DDE is a degradation by-product of DDT and has separate PSQG guidelines established for concentrations of this individual isomer in streambed sediment. Of the seven samples collected that had detections in streambed sediment, all concentrations exceeded the TEL (1.42 µg/kg). Sample

concentrations at two agricultural drain sites (site 15, 56 µg/kg; site 17, 19 µg/kg) greatly exceeded the PEL (6.75 µg/kg) (fig. 3). All seven of these samples were collected from agricultural and mixed land-use sites in the western part of the study unit. P,p'-DDE also was detected in 12 of 14 samples collected for whole-body fish; however, none of the concentrations exceeded NAS/NAE guidelines.

**Chlordane:** Chlordane is highly toxic to fish and historically was used as a contact insecticide until 1980 when it was banned except for termite control and wood treatment. In this fact sheet, the sum of the chlordane isomers (*cis*-chlordane, *trans*-chlordane, *cis*-nonachlor, *trans*-nonachlor, oxychlordane, and heptachlor epoxide) is referred to as "total chlordane." None of the chlordane isomers were detected in streambed-sediment samples, but some were detected in whole-body-fish samples collected at some agricultural and mixed land-use sites (fig. 2). Total chlordane concentrations for whole-body-fish samples ranged from 25.2 to 86.4 µg/kg. Whole-body-fish samples collected at site 18, an agricultural land-use site, had the highest total chlordane concentration (86.4 µg/kg) and approached the NAS/NAE guideline for whole-body fish of 100 µg/kg.

**Polychlorinated Biphenyls (PCB's):** PCB's are well-documented, persistent organochlorine compounds that have been banned since 1979. Historically, these compounds primarily were used as industrial heat-exchange and dielectric fluids used in capacitors and transformers. PCB's were detected only



**Figure 2.** Concentrations of total DDT and total chlordane in streambed sediment and whole-body fish.

in whole-body-fish samples at site 8 (fig. 4), a mining land-use site, with a concentration of 180  $\mu\text{g}/\text{kg}$ . The NAS/NAE guideline for whole-body fish is 500  $\mu\text{g}/\text{kg}$ .

**Dieldrin:** Dieldrin also has been banned from use in the United States. The PSQG guidelines for dieldrin are a TEL of 2.85 and PEL of 6.67  $\mu\text{g}/\text{kg}$ . Dieldrin was detected in streambed sediment at two agricultural drain sites (15 and 16); however, only site 15 exceeded the TEL guideline with a concentration of 3.5  $\mu\text{g}/\text{kg}$  (fig. 4). Dieldrin was the second most frequently detected organochlorine compound (5 of 14 sites) in whole-body-fish samples. Concentrations of dieldrin in whole-body-fish samples occurred predominantly at agricultural land-use sites, and concentrations at all sites ranged from 6.0 to 71  $\mu\text{g}/\text{kg}$ . The highest concentration of 71  $\mu\text{g}/\text{kg}$  from site 12 was less than the NAS/NAE guideline of 100  $\mu\text{g}/\text{kg}$ .



Weighing and measuring of individual fish.

**Dacthal (DCPA):** Dacthal, more commonly known as DCPA, is used as a selective preemergent herbicide. It is considered a general hazard to fish and is the only compound analyzed for and detected

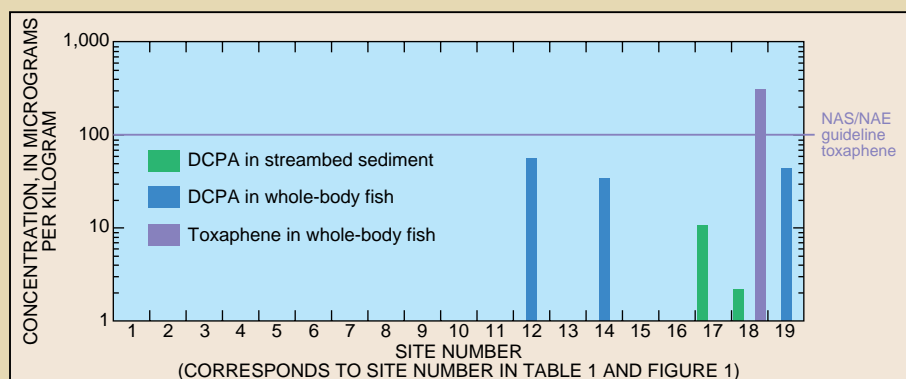


Figure 5. Concentrations of DCPA and toxaphene in streambed sediment and whole-body fish.

in this study that has not been banned from use. DCPA was detected in trace amounts in streambed-sediment samples collected at agricultural sites. The streambed-sediment sample collected from site 17 had the highest concentration at 10  $\mu\text{g}/\text{kg}$  (fig. 5). DCPA was detected in whole-body-fish samples at three sites (12, 14, and 19) with concentrations ranging from 32 to 52  $\mu\text{g}/\text{kg}$ . There are no established guidelines for concentrations of DCPA in streambed sediment or whole-body fish.

**Toxaphene:** Toxaphene (Camphchlor) was widely used as a preharvest insecticide for cotton, grains, vegetables, and fruit. Toxaphene was banned in 1982 after it was used to replace DDT as an agricultural insecticide. Toxaphene was only detected in whole-body-fish samples (fig. 5) at site 18 (300  $\mu\text{g}/\text{kg}$ ), an intensive agricultural land-use site. Concentration at this site exceeded the NAS/NAE guideline (100  $\mu\text{g}/\text{kg}$ ) for toxaphene concentrations in whole-body fish.

## Water-Quality Implications

Organochlorine pesticides and PCB's were more frequently detected and were at much higher concentrations in whole-body-fish samples than in streambed-sediment samples. Six of 33 individual organochlorine compounds analyzed for were detected in streambed-sediment samples. Eighteen of the 28 individual organochlorine compounds analyzed for were detected in whole-body-fish samples. Although the use of organochlorine compounds such as DDT, chlordane, and PCB's was discontinued in the early 1970's, all of these compounds were detected in whole-body-fish samples and, to a much lesser extent, in streambed-sediment samples collected in the UCOL study unit. The sites with the most detections and highest concentrations of organochlorine compounds in streambed-sediment and whole-body-fish samples generally were located in the western, lower reaches of the basin, which includes some mixed land use but which generally is agricultural.

Site 12 had the most detections of organochlorine compounds in streambed-sediment and whole-body-fish samples. Site 15 was sampled only for streambed sediment but had concentrations of a degradational form of DDT (p,p'-DDE) that exceeded PSQG guidelines by more than eight times the PEL. In addition, all other organochlorine compounds detected in streambed sediment at this site exceeded the TEL, and some exceeded the PEL. Concentrations of toxaphene in whole-body-fish samples collected from site 12 exceeded levels established for the protection of wildlife that consume fish.

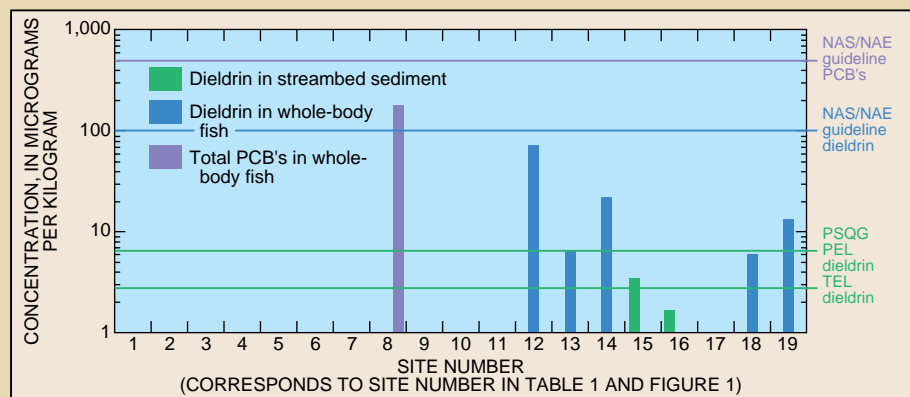


Figure 4. Concentrations of PCB's and dieldrin in streambed sediment and whole-body fish.



Assessing the implications of organochlorine pesticide and PCB concentrations in fish and wildlife is becoming increasingly important because of recent evidence suggesting that some organochlorine compounds may disrupt endocrine systems, even at low concentrations (Colburn and others, 1993). Also, the cumulative or synergistic effects associated with multiple occurrences of toxic compounds are not well understood or documented. Although most of the organochlorine compounds detected in the samples from the study have been banned, the environmental degradation of these compounds is slow; therefore, organochlorine compounds such as DDT, chlordane, and PCB's remain in the UCOL study unit long after use has been restricted.



Whole-body-fish sample processing.

## References Cited

- Apodaca, L.E., Driver, N.E., Stephens, V.C., and Spahr, N.E., 1996, Environmental setting and implications on water quality, Upper Colorado River Basin, Colorado and Utah: U.S. Geological Survey Water-Resources Investigations Report 95-4263, 34 p.
- Colburn, T., van Saal, F.S., and Soto, A.M., 1993, Developmental effects of endocrine-disrupting chemicals in wildlife and humans: Environmental Health Perspectives, v. 101; p. 378-384.
- Crawford, J.K., and Luoma, S.N., 1993, Guidelines for studies of contaminants in biological tissues for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 92-494, 69 p.
- Deacon, J.R., and Stephens, V.C., 1996, Summary of biological and contaminant investigations related to stream water quality and environmental setting in the Upper Colorado River Basin, 1938-95: U.S. Geological Survey Water-Resources Investigations Report 96-4172, 37 p.
- Environment Canada, 1995, Interim sediment quality guidelines: Ottawa, Ontario, Ecosystem Conservation Directorate Evaluation and Interpretation Branch, 63 p.
- National Academy of Sciences and National Academy of Engineering, 1973, Water quality criteria, 1972: U.S. Environmental Protection Agency, EPA R3-73-033, 594 p.
- Shelton, L.R., and Capel, P.D., 1994, Guidelines for collecting and processing samples of streambed sediment for analysis of trace elements and organic contaminants for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 94-458, 20 p.
- Ware, G.W., 1989, The pesticide book: Fresno, Calif., Thomson Publications, 3d ed., 340 p.

Information on technical reports and hydrologic data related to the NAWQA Program can be obtained from:

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